

Claims

What is claimed is:

1. An external fixation apparatus comprising:
 - a first member attachable to a first bone segment through pins;
 - a second member coupled to the first member through a lockable ball joint, wherein first and second ends of the second member may be translated transversely relative to a longitudinal axis of the second member; and
 - a pin clamp coupled to and rotatable about the second member through a lockable joint and attachable to a second bone segment.
2. The external fixation apparatus of claim 1, wherein the first bone segment is a tibia and the second bone segment is a talus or a calcaneus.
3. The external fixation apparatus of claim 1, wherein translation of the first and second ends of the second member relative is possible in at least two dimensions.
4. The external fixation apparatus of claim 2, wherein the second member includes:
 - a carriage that fits within an upper recess and a lower recess of the second member, the carriage including two threaded holes each receiving a worm gear; and

keybolts that operate each worm gear such that the carriage may be moved transversely to the longitudinal axis in one dimension within the upper recess and transversely to the longitudinal axis in another dimension within the lower recess.

5. The external fixation apparatus of claim 1, wherein the second member includes a unitary stem.

6. The external fixation apparatus of claim 1, wherein the lockable joint coupling the second member and the pin clamp comprises:

an axle extending through a hole in a first jaw of the pin clamp and a hole in the second end of the second member;

an anti-rotation pin inserted through a portion of the second member and into the axle; and

a first bolt that passes through openings in first and second jaws of the pin clamp such that tightening of the first bolt interferes with the axle and locks rotation of the pin clamp and the second member.

7. The external fixation apparatus of claim 1, wherein the lockable joint coupling the second member and the pin clamp comprises:

a threaded sleeve fixed to the second member; and

a core with internal hex driving sockets that is threaded onto the sleeve so that as the core is moved along the sleeve, balls are forced up ramps and into the pin clamp or allowed to move down ramps and away from the pin clamp.

8. The external fixation apparatus of claim 1, wherein the lockable joint coupling the second member and the pin clamp comprises:

a biasing element; and

a pushbutton core contacting the biasing element such that when the pushbutton core is depressed the pin clamp may rotate freely.

9. The external fixation apparatus of claim 1, wherein the lockable joint coupling the second member and the pin clamp provides for multi-axis rotation between the second member and the pin clamp.

10. The external fixation apparatus of claim 9, wherein the lockable joint coupling the second member and the pin clamp comprises:

a sphere suspended from the second end of the second member that is received within interior surfaces of first and second jaws of the pin clamp; and

at least one bolt that passes through openings in at least one of the first and second jaws of the pin clamp such that tightening of the at least one bolt interferes with the sphere and locks rotation of the pin clamp and the second member.

11. The external fixation apparatus of claim 9, wherein the lockable joint coupling the second member and the pin clamp comprises:

a sphere attached to the pin clamp; and

a compression bolt that extends through holes in the sphere of the pin clamp and the second member so that when the bolt is tightened with a lock nut, the second member is compressed against the sphere thereby locking rotation of the second member and the pin clamp.

12. The external fixation apparatus of claim 9, wherein the lockable joint coupling the second member and the pin clamp comprises:

a connector that is held within a sphere-shaped tip of the second member by a retaining cap and a biasing element, the connector having a ball end and a threaded end; and

a cooperating surface of the pin clamp that receives the sphere-shaped tip of the second member and the threaded end of the connector; and

a nut that is threaded onto the threaded end of the connector to retain the connector within the pin clamp and such that when the nut is tightened the sphere-shaped tip of the second member and the cooperating surface of the pin clamp are locked against one another.

13. The external fixation apparatus of claim 9, wherein the lockable joint coupling the second member and the pin clamp comprises:

a connector held within a sphere-shaped tip of the pin clamp;

a cooperating surface of the second member that receives the sphere-shaped tip of the pin clamp and a shaft end of the connector; and

a wedge bolt extending through the second member that is tightened by a wedge nut causing a ramp to force a ball end of the connector to be pulled up forcing the sphere-shaped tip of the pin clamp and the cooperating surface of the second member to lock against one another.

14. The external fixation apparatus of claim 9, wherein the lockable joint coupling the second member and the pin clamp comprises:

two stacked washers attached to a spherical portion of the second member;

two stacked washers attached to the pin clamp, wherein the two stacked washers of the pin clamp are alternately nested with the two stacked washers of the second member; and

a bolt extending from the pin clamp and into the spherical portion of the second member such that all of the washers and the spherical portion are pressed together upon tightening of the bolt, thereby locking rotation of the pin clamp and the second member.

15. The external fixation apparatus of claim 1, wherein the second member is biased at the second end from the longitudinal axis of the second member up to approximately sixty degrees.

16. The external fixation apparatus of claim 1, wherein the lockable joint coupling the second member and the pin clamp comprises:

a shaft extending transversely from the second end of the second member, the shaft including at least one radial groove;

a hole within a first jaw of the pin clamp that receives the shaft;

a locator pin of the pin clamp that is received within the at least one radial groove to releasably couple the second member and the pin clamp; and

a first bolt that passes through openings in the first jaw and a second jaw of the pin clamp such that tightening of the first bolt interferes with the shaft and locks rotation of the pin clamp and the second member.

17. The external fixation apparatus of claim 1, wherein the pin clamp is symmetrical or asymmetrical.

18. An external fixation apparatus comprising:

a first member attachable to a first bone segment through pins;

a second member coupled to the first member through a lockable joint, the second member including a shaft extending transversely from a distal end of the second member with at least one radial groove in the shaft; and

a pin clamp attachable to a second bone segment and releasably coupled to and rotatable about the second member, the pin clamp comprising:

a first jaw and a second jaw, the first jaw including a hole that receives the shaft;

a locator pin that is received within the at least one radial groove of the shaft to releasably couple the second member and the pin clamp; and

a first bolt that passes through openings in the first and second jaws such that tightening of the first bolt interferes with the shaft and locks rotation of the pin clamp and the second member.

19. The external fixation apparatus of claim 18, wherein a proximal end and the distal end of the second member may be translated transversely relative to a longitudinal axis of the second member.

20. The external fixation apparatus of claim 19, wherein translation of the proximal and distal ends of the second member is possible in at least two dimensions and the second member includes:

a carriage that fits within an upper recess and a lower recess of the second member, the carriage including two threaded holes each receiving a worm gear; and

keybolts that operate each worm gear such that the carriage may be moved transversely relative to the longitudinal axis in one dimension within the upper recess and transversely relative to the longitudinal axis in another dimension within the lower recess.

21. The external fixation apparatus of claim 18, wherein the locator pin is pulled to allow for release of the second member from the pin clamp.

22. The external fixation apparatus of claim 18, wherein the locator pin is pushed to allow for release of the second member from the pin clamp.

23. The external fixation apparatus of claim 18, wherein the pin clamp further comprises second and third bolts that hold the first and second jaws together and attach and clamp pins or wires to the second bone segment.

24. The external fixation apparatus of claim 23, wherein the pin clamp further comprises openings in the first and second jaws that receive biasing elements and threaded ends of the second and third bolts.

25. In an external fixation system for attaching pins or wires to at least one bone segment, the system comprising:

an external fixation device; and

a pin clamp comprising:

a first jaw and a second jaw;

biasing elements received within openings in the first and second jaws;

first and second bolts that extend through the openings in the first and second jaws, compressing the biasing elements and holding the first and second jaws together;

a hole in the first jaw that receives a shaft of an external fixation device, the shaft having at least one radial groove;

a locator pin that is received within the at least one radial groove of the shaft to releasably couple the external fixation device and the pin clamp; and

a third bolt that passes through openings in the first and second jaws such that sufficient tightening of the third bolt interferes with the shaft and locks rotation of the pin clamp and the external fixation device.

26. The pin clamp of claim 25, wherein the external fixation device is a handle such that the pin clamp and handle coupled thereto may be used as a drill guide.

27. The pin clamp of claim 25, wherein the external fixation device is a fixation component that includes a capture member that receives a pin, bar, or wire.

28. The pin clamp of claim 25, wherein the external fixation device is a second member with first and second ends that may be translated transversely relative to a longitudinal axis of the second member in at least two dimensions.

29. The pin clamp of claim 25, wherein the locator pin is pushed or pulled to allow for release of the external fixation device from the pin clamp.

30. A method of treating a skeletal condition or injury using an external fixation apparatus, the method comprising:

(a) fixing a first member to a first side of a fracture with upper bone pins, the first member being coupled to a second member through a lockable ball joint;

(b) fixing a pin clamp to a second side of the fracture with lower bone pins, the pin clamp being coupled to and rotatable about the second member through a second lockable joint; and

(c) adjusting a first end and a second end of the second member transversely relative a longitudinal axis of the second member to precisely reduce the fracture.

31. The method of claim 30, further comprising rotating the pin clamp about the second member to as desired for placement of the lower bone pins.

32. The method of claim 30, wherein the pin clamp is fixed prior to the fixing of the first member.

33. The method of claim 30, wherein the first and second ends of the second member may be adjusted transversely relative to the longitudinal axis of the second member in at least two degrees of freedom.